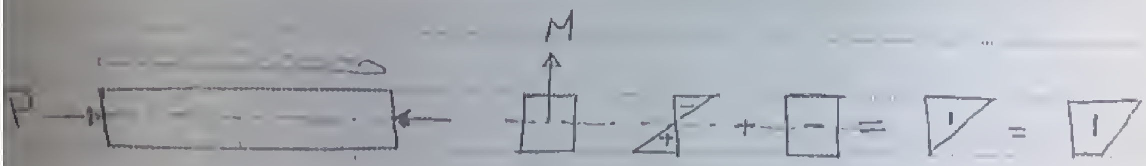
# Pre Stressed Concrete

خرسانة سابقة الإجهاد

introduction :-

The idea of prestressing was introduced to over come the main disadvatage of concrete, which is low tensile stress, through introducing compressive longtudinal force (Pre stressing force). The prestressing force eleminate the tensile stress at tension zone which is the main objective prestressing force




نضع normal force التي تولد مزدوج على الأسرا يادل tensile stress الموجود على القطاع التي يكون الناتج no tensile stress

* advantages of prestressing

1- Prevent the tensile stress and so there is no cracks at tension zone لا يفيد في تقليل سمك القطاع

2 reduce the total depth of section

3- تحسين in harced the moment of internal of the cross section and there fore decreasing the deflection تقليل الهبوط

dis advatages

high Cost due to using high stress material

loss of Prestressing force

Complecated detailes and technolage are required

في التسليح

- Classifications of Prestress

There are two Method of Prestrssed

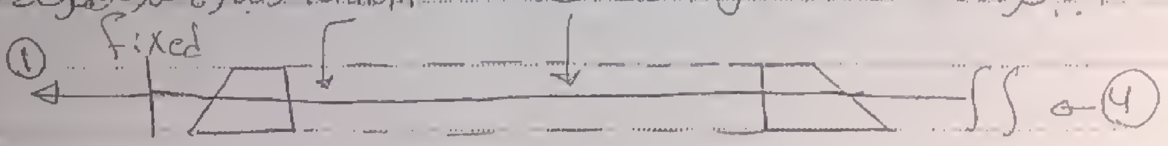
pre tension Method

Post tension method

Pre tension method خرسانات سابقة الصب زي الحامل

This Method is used for pre Casting, The steel (tendoms) are tension before the Concrete is placed and after The Concrete is harding The steel is cut and the Prestressed force will be applied at sec كبل حديد

مربوط من ... Tendom ② Casting Concrete صب الخرسانة




① tendom شد الـ

② Casting of Concrete

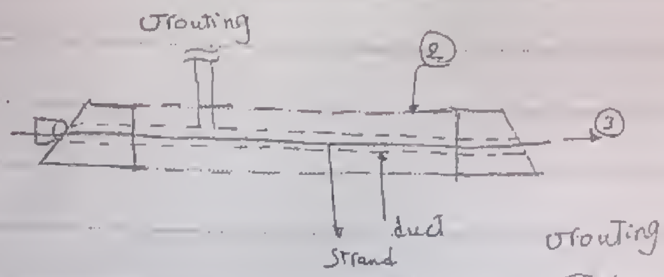
③ after harding of Concrete بعد تصلب الخرسانة نيجي نقطع الحديد

tendom انيجي نقطع من ... في الاتجاه ... لا من

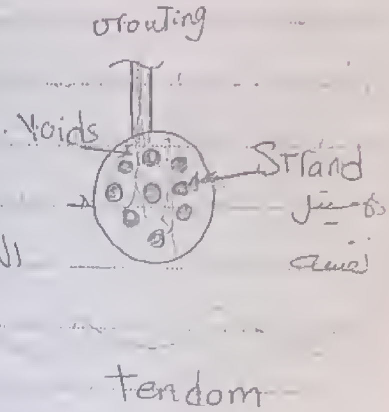
point of cutting ... اقطع الحديد من اتجاه ... cutting ...

## ② Post tension Method

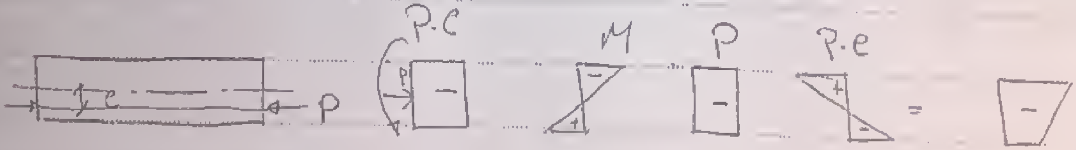
iT is used for situTion في الموقع
The sTeel tendom is sTressed after Concrete is harding.



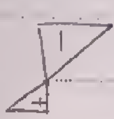

1) Put tendom without tension
2- Casting of Concrete
3- STressed of sTeel الدبلفاشل سيتل
4- Cutting



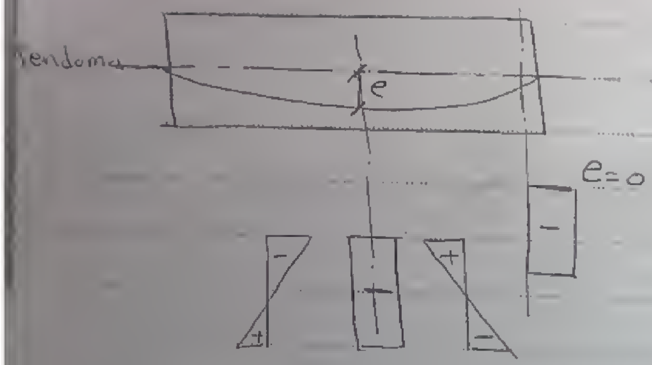

* Concept of Pre sTress
flecturestress in pre sTress member are the result of pre sTressed force, the internal MoMent due to ecentric, tendom Confeguration (P·e) and the applied MoMent

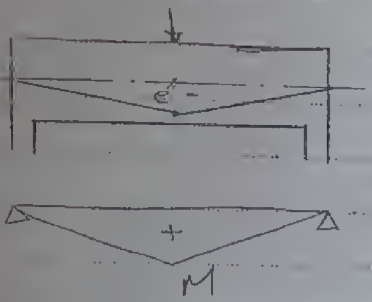


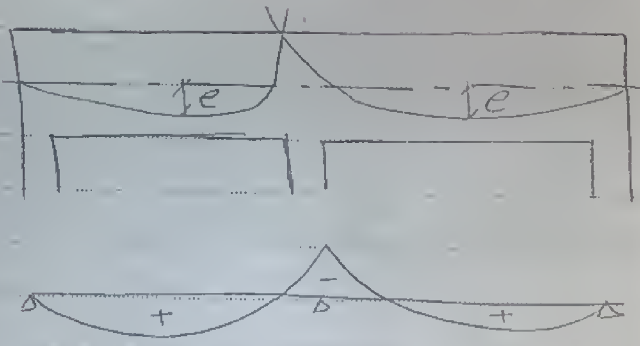

⇒ sTress لو شكل بيدك

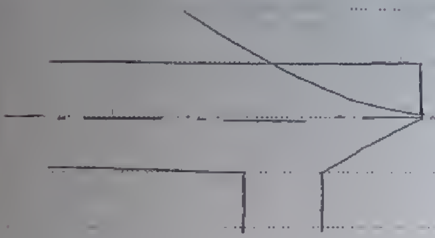


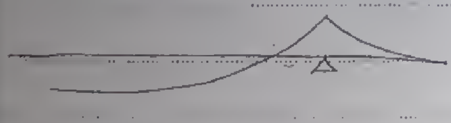
- لما نزود tandum , بالتالي زيادة التكلفة
او نعمل eccentricity لزيادة الافادة
يتم وضع tandum ع شكل العزم

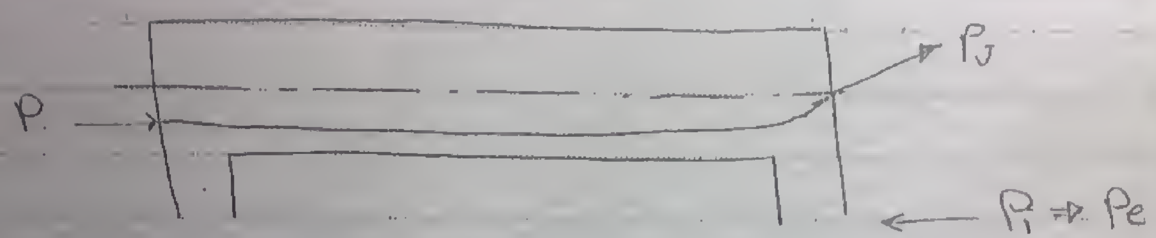

tendons
e
e=0


e'
M


e
e








$P_i < P_j \Rightarrow$ initial immediatal

$Pe < P_i \Rightarrow$ time independent loses

$P_J \xrightarrow[\text{Losses}]{\text{immediately}}$ $\qquad$ $P_i \xrightarrow[\text{losses}]{\text{time independant}} Pe$

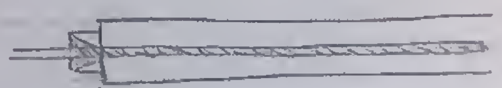
The applied prestressing force after Jacking under go, number of Reduction of force are occure. Sum of this Reduction occure imediatly and other occure over aperiod of time

The losses of forces intendom is Ranging from (10 → 25) of the jacking force

* losses      losses in prestressed Concrete

| * Types of losses | Pretension | Posttension |
| --- | --- | --- |
| 1) Slip of anchorage<br>انزلاق الصلب عند نقاط التثبيت | X | ✓ |

يحدث في Post tension لأن الضغط الخارجي في هذه الحالة عند ارتداد الـ ndon
و ضغطه ع القطاع Conical يمكن ان ينزلق و يحدث فقط في rce



| | Pretension | Post |
| --- | --- | --- |
| (2) elastic shortening<br>$\Delta E_{ES}$<br>نقص في طول الكمرة نتيجة قوة الانضغاط | ✓ | ✓ |

← يحدث في هذه الحالة فقدان جزء من القوة نتيجة انضغاط الخرسانة
اثناء ارتداد الـ tendom ويحدث ف pre و post

| | | |
| --- | --- | --- |
| (3) friction<br>$\Delta E_{FR}$ | X | ✓ |

← الثلاث حالات تعتبر Immediately losses

Date:

time indepent losses

| | Pretension | Posttension |
|---|---|---|
| 4- shrinkage $\Delta F_{psh}$ | ✓ | ✓ |
| 5- creep $\Delta F_{pc}$ | ✓ | ✓ |
| 6- Reducation of steel $\Delta F_{PR}$ | ✓ | ✓ |

4- فقدان الخرسانه نتيجه للانكماش

5- فقدان ال force نتيجه ارتخاء ال tendom داخل الكمره

$\boxed{1}$ anchorage slip losses $(\Delta F_{AS})$

assume slip anchorage $(\Delta S) = 0.2$ cm $(2-6)$ mm

Modulus of elasticity $E_{ps} = 2 \times 10^6$ kg/cm²

$= 2 \times 10^5$ N/mm²

$$\Delta F_{AS} = \frac{\Delta S}{L} \times E_{ps}$$

$L \rightarrow$ length of tendom

$\Delta F_{AS}$ = losses of stress

## [2] elastic shortening ($\Delta f_{ES}$)

* for pre-tension when prestressing force is transfer to The concrete, The concrete shorten is occured and part of th prestressing is lost

$$\Delta f_{ES} = \frac{f_{pci}}{E_{ci}} * E_{ps}$$

where

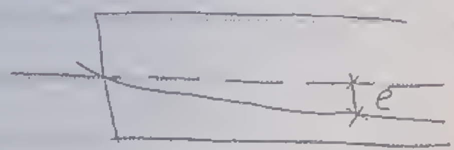
$$f_{pci} = \frac{-P_i}{A} - \frac{P_i * e * e}{I} + \frac{M_{o.w} * e}{I}$$

$\Delta f_{ES}$ = lossesof stress

$$E_{ci} = 14000 \sqrt{f_{cui}}$$

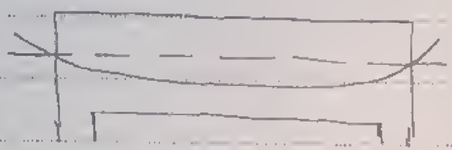
$$f_{cui} = 0.45\ f_{cu}$$

$$E_{cui} = 4400 \sqrt{f_{cui}} \quad N/mm^2$$




* for Post-tension

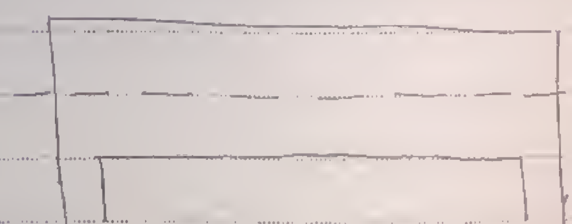
$\Delta f_{ES}$ = zero → for one tendom



→ for more one tendom

$$\Delta f_{ES} = \frac{1}{2} \frac{f_{pci}}{E_{ci}} * E_{ps}$$

* ذكرنا إن one tendom بيعادل
العزم الناتج من eccentricity

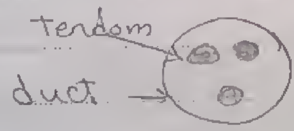


Page:

Date:

$\boxed{3}$ Friction losses $(\Delta f_{FR})$

This type of losses exist only in post tention due to the friction between the tendom and the frounding duct




$$\Delta f_{FR} = f_p(KL + \mu \alpha)$$

where

$\mu$ = is the frictnon coefficient

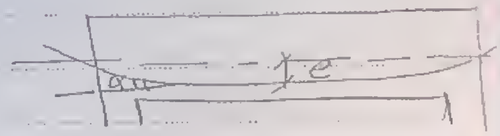
$\alpha = \frac{2e}{L}$

$K = 0.003 / m$

$L$ = length of beam

$f_p = f_{PJ} - \Delta f_{AS}$

$f_{PJ} =$




wher

$P_J$ = Jacking force

$f_P$ = Area prestress steel

* long term losses (time independent losses)

[4] Shrinkage losses ($\Delta f_{psh}$)

$$\Delta f_{psh} = \varepsilon_{sh} * E_{ps}$$

$\varepsilon_{sh} = 0.3 * 10^{-3}$ Pre - tension

$= 0.2 * 10^{-3}$ Post - tension

[5] Creep losses ($\Delta f_{pc}$)

$$\Delta f_{pc} = \varepsilon_{cr} * E_{ps}$$

$\varepsilon_{cr} = 0.48 * 10^{-3}$ Pre -

$\varepsilon_{cr} = 0.36 * 10^{-3}$ Post.

[6] Relaxation steel losses ($\Delta f_{pR}$)

is defined as the losses of stresses under constant strain and occure due to longation the tendom with time

$$\Delta f_{pR} = f_{pi} * \frac{\log 1000}{10} * \left[ \frac{f_{pi}}{f_{py}} - 0.55 \right]$$

where

$$f_{pi} = \frac{P_i}{A_{ps}}$$

$$f_{py} = 0.85 f_{pu}$$

($f_{py}$) The yielding stresses of prestressing steel

$$f_{py} = (0.85 - 0.9) f_{pu}$$

- يتم استخدام حديد عالي المقاومة لتوفير قطع الخرسانة

+ الحديد اللازم لتولد القوه tension اللازمة

Page:

Date:

$f_{pu} = 1900$

$F_{psw} = 0.7\ f_{pu}$

$= 0.8\ f_{pu}$ } الأكبر

ـه لا يزيد عن القيمه $f_{pu}$ حتى لا يحدث Yeild forced

→ For the given Section, it is required to fined The % of losses in The Following Cases

① Pre-Tension

② Post-tension

Given:

$A_{ps} = 300\ mm^2$

$P_i = 350\ KN$

$f_{cu} = 35\ N/mm^2$

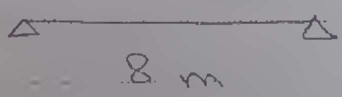
$P_i = 350\ KN$

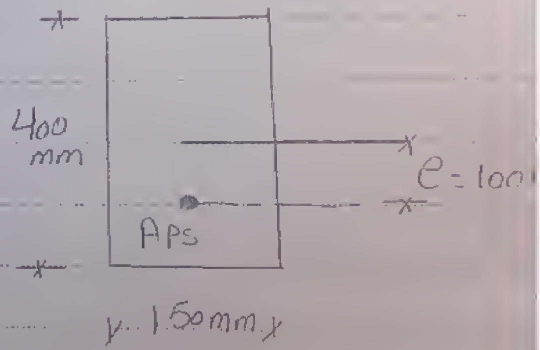
$E_{ps} = 2.1 * 10^5\ N/mm^2$

anchorage strip = 2 mm

$L = 8000\ mm$

Steel grade 270 $f_{pu} = 1900\ N/mm^2$




Sol:

* Properties of section

- $A_s = 150 * 400 = 60000$

- $I = \frac{150 * 400^3}{12} = 80000 * 10^4$

- $O.W.T = 0.15 * 0.4 * \underset{KN/m^3}{25} = 1.5\ KN/m$

- $M_{O.L} = O.W.T * \frac{L^2}{8} = 1.5 * \frac{8^2}{8} = 12\ KN \cdot m$

Date: ........

$$\rightarrow f_{pci} = -\frac{P_i}{A} - \frac{P_i * e * e}{I} + \frac{M_{o.w.t} * e}{I}$$

$$\frac{350}{60000} - \frac{350 * 10^3 * 100 * 100}{80000 * 10^4} + \frac{12 * 10^6 * 100}{80000 * 10^4} = -6.8 \ N/m$$

$$\rightarrow f_{pi} = \frac{P_i}{A_{P_s}} = \frac{550 * 10^3}{300} = 1166.7 \ N/mm$$

$$\rightarrow E_c = 4400\sqrt{f_{cu}} = 4400\sqrt{35} = 23030.8 \ N/mm^2$$

$$\rightarrow f_{cui} = 0.75 f_{cu} = 0.75 * 35 = 26.26 \ N/mm^2$$

$$\rightarrow E_{ci} = 4400\sqrt{f_{cui}} = 4400\sqrt{26.26} = 22543.3 \ N/mm^2$$

assume immediatly losses = 10%.

$\therefore \ P_i = (1 - 0.1) P_J$

$350 = 0.9 * P_J \qquad \therefore \ P_J = 388.89 \ KN$

$$f_{pj} = \frac{388.89}{300} = \frac{P_J}{A_{P_s}} = 1296.3 \ N/mm^2$$

Date:

for immediatly losses

## Pre-tension

① anchorage slip

Zero %

② elastic shorting

$\Delta f_{ES} = \frac{f_{pci}}{E_{ci}} * E_{ps}$

$= \frac{6.87}{2254} * 2 * 10^5 = 6.94$

③ Friction losses

$\Delta f_R = Zero$

$\Sigma = 4.7\%$

## Post tension

①

$\Delta f_{AS} = \frac{\Delta S}{L} E_{ps}$

$= \frac{2}{8000} * 2 * 10^5 = 5 \ N/mm^2$

$\% \text{ of losses} = \frac{\Delta f_{AS}}{f_{pj}} = \frac{5}{1296.3} = 3.85\%$

②

$\Delta f_{ES} = $ Zero % One tendam

③

$\Delta f_R = f_p [KL + \mu \alpha]$

$f_p = f_{pJ} - \Delta f_{AS}$

$= 1246.3 \ N/mm^2$

$\therefore \Delta f_R = 1246.3 [0.003 * 8 + 0.3 * 2 * \frac{100}{8000}]$

$\% \text{ of losses} = \frac{59.25}{1296.3} * 100$

$= 3.02$

$\Sigma = 6.87$

→ for long term losses

Pre

① Creep

$\Delta f_{pi} = \varepsilon_{cr} \times E_{ps} = 96$

$= 0.48 \times 10^{-3} = 96$

% of loss $= \frac{96}{1296.3} = 7.4\%$

② Shrinkage

$\Delta f_{sh} = \varepsilon_{sh} \times E_{ps}$

$= 0.3 \times 10^{-3} \times 2 \times 10^{5} = 60\ N/mm^2$

Post

①

$\Delta f_{pi} = 0.36 \times 10^{-3} \times 2 \times 10^{5} = 72$

% loss $= \frac{72}{1296.3} \times 100 = 5.55\%$

②

$\Delta f_{sh} = 0.2 \times 10^{-3} \times 2 \times 10^{5}$

$= 40$

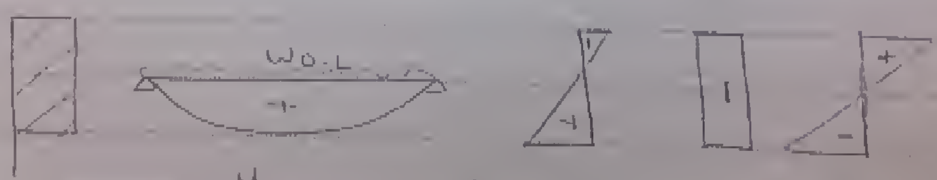
% loss $= \frac{40}{1246} = 3.08$

* loading Stage

inThe stage of Construction , the initial prestressing force and the dead load construction are effect on The normal stress This stage is as initial stage alltransfer .
The charactristic strength in Concrete .
$f_{cui} = 0.75 f_{cu}$

inThe stage of surface building , The prestressing force [initial pre-stressed is refused to [PE] final prestressed force and the life load of building , this stage is known as final stage or service stage on

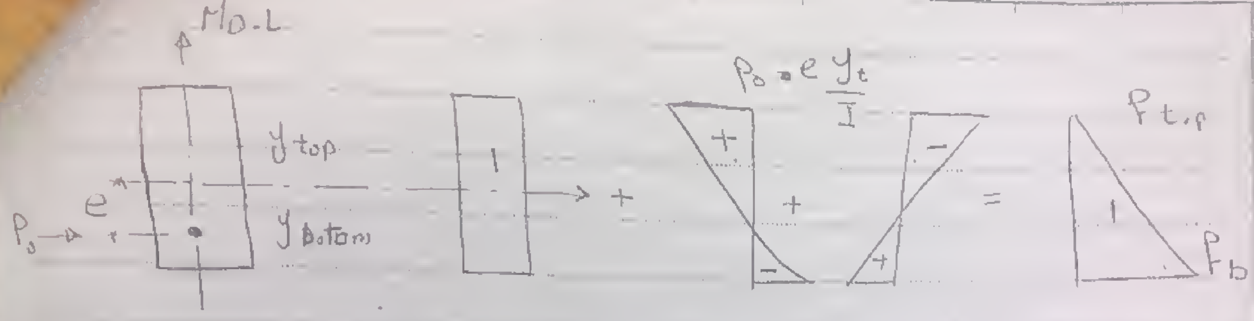
① Transfer stage (initial stage due to dead load + $P_n$) / working load (elastic zone without cracks)




$M_{O.L} = \frac{W_{O.L} \times L^2}{8}$

Page:

Date:




$$F_t = -\frac{P_o}{A} + \frac{P_o \cdot e \cdot y_t}{I} - \frac{M_{O.L}\, y_t}{I} \leq 0 \qquad \ngtr 0.22\sqrt{F_{cui}}$$

Critical هي
at initial stage

$$F_b = -\frac{P_o}{A} - \underset{\text{compression}}{\frac{P_o \cdot e \cdot y_b}{I}} + \frac{M_{O.L} \cdot y_b}{I} < \underset{\text{طبقا للكود}}{0.45\, F_{cui}}$$

$P_o \leftarrow$ Transfer stage قوى اكبر تأثيرها في

$F_t \rightarrow$ تعتبر حالة Critical و لذلك لا بد من ان تكون

اقل من صفر حتى لا يتولد . شرخ الخرسانة او يسمح بشرخ

لا يزيد عن $0.22\sqrt{F_{cui}}$

لـه tensile stress

Date:

② at working Stage (final Stage due to (D.L + L.L + Pe)

Pe → final prestress force

$$P_e < P_o$$

$$f_t = -\frac{P_e}{A} + \frac{P_e \cdot e \cdot y_t}{I} - \frac{M_{(D.L + L.L)} \cdot y_t}{I} \ngtr 0.4\, f_{cu}$$

(D.L + L.L)

$$f_b = -\frac{P_e}{A} - \frac{P_e \cdot e \cdot y_b}{I} + \frac{M_{(D+L)} \cdot y_b}{I} \leq 0$$

$\ngtr 0.44\sqrt{f_{cu}}$

$\ngtr 0.85\sqrt{f_{cu}}$

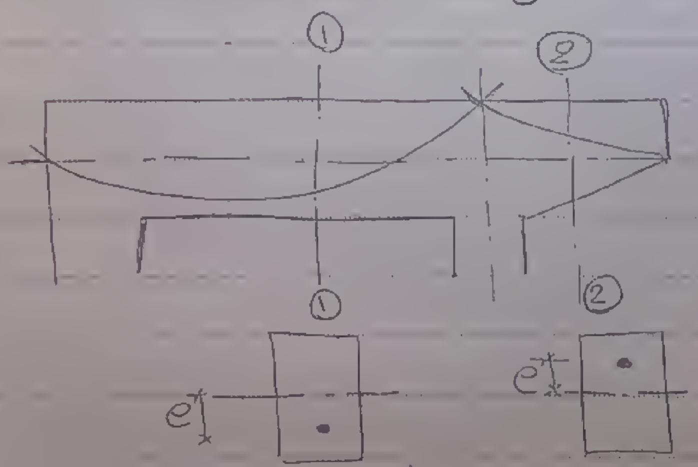
Critical at final stage

$0.44\sqrt{f_{cu}}$ → full prestressed — without crack

$0.85\sqrt{f_{cu}}$ → Partially " — with crack

وبالتالى لابد من وجود حديد للتغلب على $0.85\sqrt{f_{cu}}$

دا الـ deflection سوف يتأثر




حالات وجود C.g فى

نفس الفواصل السابقة للقطاع ①–①

Date:

حدوث حالات القطاع (2-2)

① at Transfer stage

$$f_t = \frac{-P_i}{A} - \frac{P_i\, e_i\, y_t}{I} + \frac{M_{O.L}\, y_t}{I} \leq 0.45\, f_{cui}$$

$$f_b = \frac{-P_i}{A} + \frac{P_i\, e\, y_b}{I} - \frac{M_{O.L}\, y_b}{I} \leq 0.0 \quad \ngtr 0.22\sqrt{f_{cui}}$$

② at working stage

$$f_{tp} = \frac{-P_e}{A} - \frac{P_e\, e\, y_t}{I} + \frac{M_{O.L+L.L}\, y_t}{I} \leq 0$$

$$\ngtr 0.44\sqrt{f_{cu}}$$

$$f_b = \frac{-P_e}{A} + \frac{P_e\, e\, y_b}{I} - \frac{M_{O.L+L.L}\, y_b}{I} \leq 0.4\, f_{cu}$$

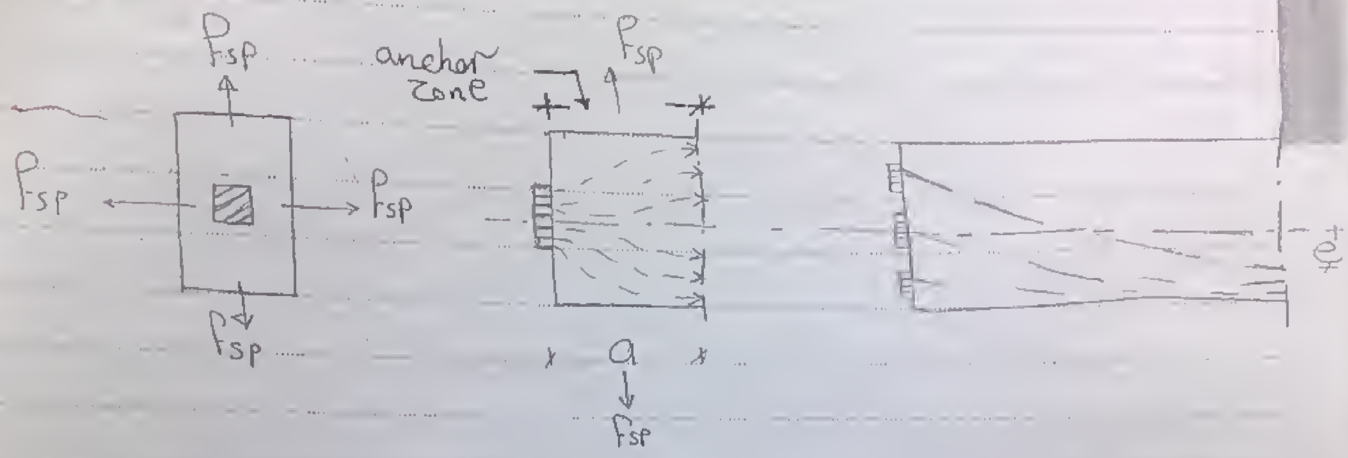
* given an area of tendom (Asp)
* Req: de Prestressing force. check of transfer stre

$$\left. \begin{aligned} f_{sall} &= 0.7\, f_{pu} \\ &= 0.8\, F_{py} \end{aligned} \right\}$$ أقل

$$P_{jack} = A_{sp} * f_{sall} \longrightarrow \underbrace{P_i}_{initial} \xrightarrow[steel]{reduci} P_e$$

* anchorage Zone

⟹ for Post tension method




الـ Fsp تنتج لان الاجهاد كان مختصر ثم حدث له توزيع متوجد في Plan & elevation

نسبياً

In post tension Structure relativley Small anchorage Plate transfer The force from the tendom to the Concrete by bearing.

anchorage Zone behind the anchorage plate May be damage due to un Controled cracking or spliting of The Con Crete (due to un Suficent transverse transfer force.

Bearing Failure immediatly behind the anchorage Plate are also Common because of theineduate

عدم كفاية / مناسبا للابعاد

dimension of the bearing Plate for Poor Quality Concrete

Page: ........ Date: ........

المشكلات التى تحدث

① anchorage plate يسبب crashing stress الناتج نقل check of bearing

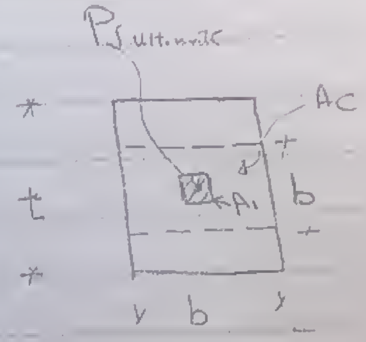
ولو unsafe زود مساحة Plate

②

لابد من وجود حديد حلزونى وكانات لتقاوم ... $f_{spl}$

→ check of bearing

crashing حيث تحدث




$$f_b = \frac{P_{ju}}{A_1} < f_{buc}$$

where

$f_b$ → bearing stress

$P_{ju}$ → ultimate jacking load

$A_1$ → area of bearing — المساحة المعرضة لمكان tendom

$$\Rightarrow f_{buc} = 0.67 \frac{f_{cu}}{1.5} \sqrt{\frac{A_2}{A_1}}$$

with condition لايزيد $\sqrt{\frac{A_2}{A_1}} \ngtr 2$

لو unsafe ← ابدأ بزيادة Aplate

- او تقسيم tendom الى اجزاء

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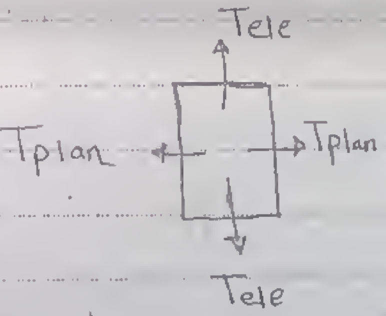
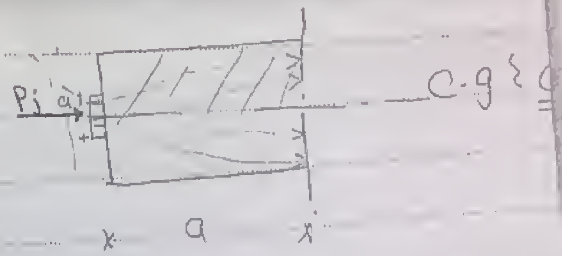
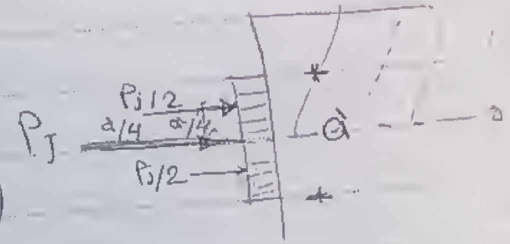
## ⇒ Design of end block (Tplans Tele) Fspl




→ in elevation

$\sum M_o = 0.0$




$$\left(\frac{P_j}{2} \cdot \frac{\grave{a}}{4}\right) + T\left(\frac{e}{2}\right) = \frac{P_i}{2}\left(e/4\right)$$

$$T_{ele} = \frac{P_i}{4} * \left(\frac{a - \grave{a}}{a}\right)$$ à → plate hight ← for one tendom

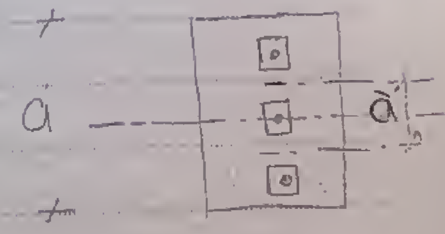
a ← ارتفاع القطاع

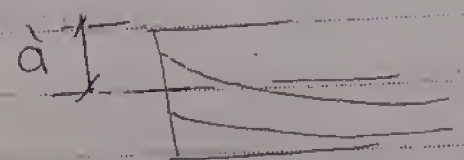
→ for more one tendom

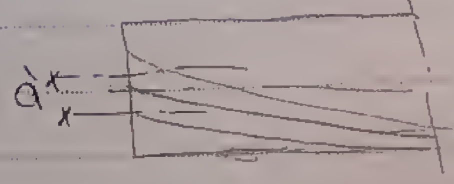
$$T_{ele} = \frac{P_i}{4 * n_{ele}} * \left(\frac{a - \grave{a}}{a}\right)$$

$n_{ele}$ ← عدد elevations plate

= 3




لو 2 tendons : à المحصور edge و C.L

لو اكثر من 2 à هي المحصورة بين C.L و C.L

← لابد من وضع كانات في منطقة anchorage لتوزيع كانات

رأسية لتقاوم Tele ناتجة من tendon واحد فقط

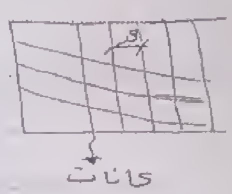
$$T_{ele} = n * A_{st} \left(\frac{a'}{S'}\right) f_s$$

$n$ ← عدد فروع الكانة

$A_{st}$ ← مساحة مقطع الكانة

$S'$ ← المسافة بين فروع الكانات

$f_s$ ← (1400 - 2000)



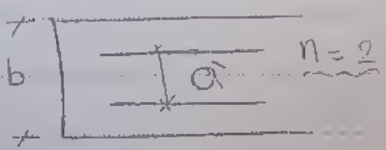

$S \ngtr 200mm$

→ in Plan

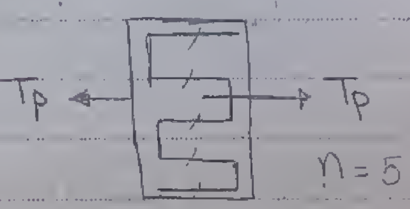
Two tendom المسافة بين = (10 - 15 cm)

$$t_{plan} = \frac{P_j}{4 * n_{plan}} \left[\frac{a - a'}{a}\right]$$

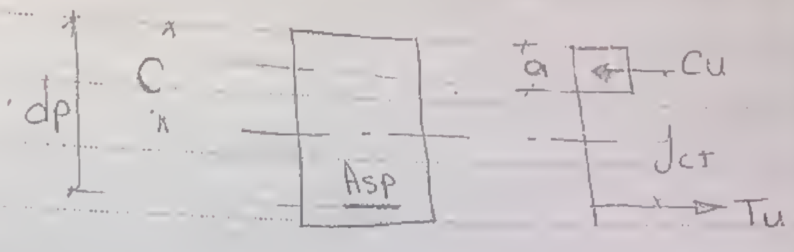
$$T_{plan} = n * A_{st} * \frac{a'}{S'} * f_s \qquad a = b$$




Plan



# check of ultimate moment




$$C_u = T_u$$

$$\frac{0.67\, f_{cu}}{\gamma_c} * a * b = \frac{A_{ps} * f_y}{\gamma_s}$$

$$M_{u.L} = T_u * (d_p - a/2)$$

$$= A_{ps} \frac{f_{yps}}{\gamma_s} * \left(d - \frac{a}{2}\right)$$

لازم $\gamma M_{u.R} > M_f$

في الحالات العاديه $M_f = 1.4\, M_{D.L} + 1.6\, M_{L.L}$

في حالات الكباري
$$M_f = 1.5\, M_{D.L} + 2.5\, M_{L.L}$$
$$= 2\, M_{D.L} + 2\, M_{L.L}$$
الأكبر

if $M_{uR} < M_f$ ∴ unsafe

الحل ـ تكريشي

(a) increase depth

(b) use non-pre tension steel ← تعويض [illegible] ضغط

ولكن القطاع يا Compression failure اي ينهار [illegible] (فجأة)

$\frac{c}{d} < \frac{c}{d_{max}}$ [illegible] لا يحصل شرط